A semiconductor component including one or more pressure-contact junctions

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Inventor(s):
Applicant(s): SIEMENS AG
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- NO119600 (B)
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more >>

Abstract of **GB 1132748 (A)**

1,132,748. Semi-conductor devices. SIEMENS - SCHUCKERTWERKE A.G. 21 June, 1966 [22 June, 1965], No. 27763/66. Heading H1K. In a semiconductor device a pressure contact in the current path is made to or through a porous sintered body of high heat conductivity. The body, preferably having a porosity of 2-40% may consist of silver, copper, silver mixed with copper, cadmium, nickel, graphite, molybdenum sulphide or tungsten selenide; or of copper mixed with graphite, molybdenum sulphide or tungsten selenide. If desired, the body may comprise two layers. One of the layers may consist of or contain a lubricant and the other not, or one layer may be of a cheaper metal than the layer used as the pressure contact face. Examples of both kinds are given ; A typical rectifier, illustrated in Fig. 4, consists of a silicon body alloyed with aluminium to a molybdenum plate 14 at one face and alloyed with gold antimony at the other. The assembly is clamped to the copper base through sintered disc 17 by the conventional spring assembly shown. In this case the upper contact is a molybdenum plate 20 hard soldered to copper rod 18. Alternatively, a sintered pressure plate may be sintered to the face of the molybdenum plate or disposed between it and the gold antimony layer. In other arrangements the silicon body with alloyed faces is disposed between metal diaphragms through the intermediary of sintered discs, the diaphragms being connected at their peripheries by a ceramic ring to form a housing.; In Fig. 6, the element is soldered between two molybdenum members 40, 41, one of which, 40 has a silver plate attached to its lower face, and mounted in a similar housing. In this case a sintered silver plate 49 is clamped between one face of the housing and a contact member 48 designed to provide cooling.

FIG. 6

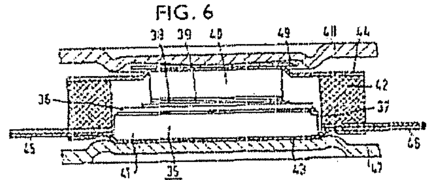
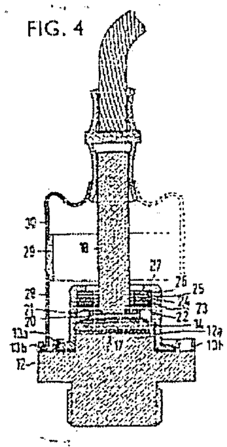


FIG. 4



PATENT SPECIFICATION

1,132,748

DRAWINGS ATTACHED.

1,132,748

Date of Application and filing Complete Specification: 21 June, 1966. No. 27763/66.

Application made in Germany (No. S97721 VIIIc/21g) on 22 June, 1965.

Complete Specification Published: 6 Nov., 1968.

Index at Acceptance:—H1 K(1A1, 1CX, 2S1A, 2S2A, 2S11G, 2S20, 4C9A, 4F1A, 4F2A, 4F5, 4F6, 4F7, 4F8, 4F9, 4F11G, 4F11S, 4F18, 4F19, 4F21, 5A).

Int. Cl.:—H 01 l 1/14.

COMPLETE SPECIFICATION.

A Semiconductor Component including One or More Pressure-Contact Junctions.

We, SIEMENS-SCHUCKERTWERKE AKTIENGESELLSCHAFT, a German Company of Berlin and Erlangen, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a semiconductor component including at least one pressure contact junction, which semiconductor component may be a junction rectifier, a junction transistor or a thyristor having laminar pn-junctions and may be produced, for example, on the basis of a semiconductor body consisting of silicon.

In the case of pressure contact rectifiers, for example, a silicon disc having a pn-junction is contacted with plane metal plates under pressure.

The silicon disc is often alloyed to a molybdenum disc on one surface by way of aluminium, and alloyed on the other surface to a gold disc, preferably of gold-antimony alloy. The pressure contact face on one side of the molybdenum disc, for example of silver, and that on the other side of the silicon disc, for example of gold, and those metallic contact faces of the counter-contacts which press against them must meet very high requirements in regard to low surface roughness. The usual surface processing methods such as fine grinding and lapping are time-consuming and relatively costly factors in the manufacture.

An object of the invention is to provide semiconductor components of this type having at least one pressure contact junction, which are so constructed that only a relatively small resistance is set up at the junction to the flow of electric current and to the flow of heat. The invention proceeds from the observation that, for achieving this object, it is necessary to provide a satisfactory laminar junction between the interengaging faces.

According to the present invention there is provided a semiconductor component including a pressure-contact junction which incorporates a sintered porous disc of good electrical and thermal conductivity, as an intermediate or junction body.

The degree of porosity of such a disc according to the invention may be between 2% and 40% and the disc may consist of metal or of a metal-containing composite material. Pure silver or pure copper or silver alloyed with copper or cadmium are particularly suitable as material for sintered discs, as also are composite metals such as, for example, silver with nickel, or composite materials of silver-graphite, silver-molybdenum (IV) sulphide or silver-tungsten selenide, copper-graphite, copper-molybdenum (IV) sulphide or copper-tungsten selenide. A lubricant component such as graphite, for example, employed in such a composite material has the object of facilitating the relative movement which occurs, as a result of the differing thermal expansions of the adjacent bodies, between those faces of the adjacent bodies which are pressed together, and avoiding welding of the interengaging contact faces. The proportion of additional metal introduced into the alloy base metal, or of graphite or molybdenum (IV) sulphide in composite material, is between about 1% and 10% by weight.

A sintered silver disc may with advantage be built up, for example, in two layers, one

of which consists of silver-graphite, for example, and the other of sintered pure silver. It is produced by common pressing of the powders banked or stacked one upon the other in a die and sintering of the pressed material.

A sintered disc built up of two layers may also be employed. The layers may consist of metal/metal or metal/metal-lubricant components. In the case of the two-layer discs consisting of metal/metal, the metal properties and the cost of the materials are primary factors. Thus, for example, a pure sintered silver disc may be replaced by a two-layered sintered disc having a sintered copper portion of predominant thickness and an inner pure silver layer. A further reason for the use of two-layer discs may deside in that the necessary total thickness of the semiconductor component is thus economically provided by a sintered copper portion of appropriate thickness in the two-layer copper disc. Thus, the thickness of the sintered disc may also consist mainly of cheap sintered copper material in order to produce a minimum overall height for the semiconductor component. Such a construction is not in practice inferior in its technical properties to a sintered disc consisting of pure silver.

In the case of the two-layer sintered disc consisting of metal/metal-lubricant component, the metal layer may consist, for example, of pure silver or pure copper and the second layer, for example, of silver-graphite, copper-graphite, silver-molybdenum (IV) sulphide, copper-molybdenum (IV) sulphide, silver-tungsten selenide or copper-tungsten selenide. The lubricant component may in this case reduce or prevent welding when the sintered silver or copper disc is pressed against the semiconductor face or metallic counter-face, since better sliding of the two contacting faces in the course of the temperature fluctuation of the component is possible.

Thus, in accordance with the invention, such a sintered porous disc or metallic sintered disc may be present only on one contact surftce of the semiconductor component or on both surfaces or on a number of contact surfaces of the semiconductor element.

The sintering process for the production of such a sintered disc and the material which is to be sintered therein should be so chosen that a plastic deformation may occur under the effective pressure produced between the pressure contact faces, so that the surface of the sintered metal disc is as completely and uniformly as possible applied against the other contact face or the counter-contact face, but this sintered disc is a body which is substantially pressure-resistant during operation.

By a slight after-pressing of the sintered body between plane dies having high surface quality, the surface roughness can be reduced.

After the sintering operation, the sintered body may be further worked in regard to its shape and/or volume.

Such a sintered disc consisting of pure silver will be employed with particular advantage. The geometry of such a sintered disc may be adapted to the semiconductor element. For example, it may have a round, square or hexagonal peripheral shape.

In accordance with the invention, the thickness of the sintered disc is between 0.1 and 2 mm., and preferably between 0.2 and 0.5 mm. The packing degree of the sintered disc is between 0.6 and 0.98. The material and the conditions are so chosen that the packing degree is not substantially reduced. The porosity is then in the aforesaid range between 2% and 40%. The pores in the sintered disc should be as fine as possible and uniformly distributed. It is particularly advantageous to employ sintered discs which have been produced from metal powders having fine, very highly loosened powder particles, for example metal powders produced by electrolysis and reduction.

The porous sintered disc lying between the corresponding contact faces not only eliminates the unevenness between the faces brought into pressure contact, but also the effects due to the differing expansion coefficients, for example of silicon ($3.7 \cdot 10^{-6}$ $°C^{-1}$), or of the generally alloyed molybdenum ($5 \cdot 10^{-6} °C^{-1}$) and of the metal employed for the contact body, for example copper ($16.5 \cdot 10^{-6} °C^{-1}$).

For the production of a porous sintered disc, for example a sintered silver disc consisting of pure silver, electrolytic silver powder having a grain size < 60 μm is preferably compressed in a steel die under a pressure of 0.5 Mp/cm^2 (megapond per square centimetre). For example, the pressed disc may have a diameter of 5 mm., a height of 0.31 mm. and a weight of 0.0322 g. The density in the pressed state is then 5.30 g/cc. and the packing degree in the pressed state 0.505. The sintering takes place at 700° C. for one hour in a hydrogen atmosphere. The linear sintering shrinkage is about 5%, the density of the sintered disc 6.32 g/cc. and the packing degree 0.602.

Powder mixtures consisting of electrolytic silver powder with copper, cadmium, graphite, molybdenum (IV) sulphide or tungsten selenide powder may also be correspondingly worked.

The metallic sintered discs employed in accordance with the invention may be readily plastically deformed in the foregoing sense. When metallic faces are pressed on to the sintered disc, the surface roughness

of these faces is pressed into the surface of the porous sintered disc even under a pressure of < 1 kp/mm². A very good metallic contact and low electrical and thermal contact resistances are thus set up. When the materials contacted by this sintered disc have differing expansion coefficients, temperature fluctuations result in relative movements between the contacting faces, but these are taken up harmlessly by the porous sintered disc partly as plastic deformations and partly as elastic deformations.

The assembly of the semiconductor component with one or more porous sintered silver discs may be repeatedly performed without the action of the sintered silver disc plastically deformed in the surface layer being reduced. Even when the assembly was repeated 10 times, no difference in the contact resistance could be observed.

In order that the invention may be more clearly understood several embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings in which,

Figure 1 illustrates one construction of a pressure contact rectifier,

Figure 2 illustrates a pressure contact rectifier similar to that shown in Figure 1 but having a differently constructed semiconductor element,

Figure 3 shows an exploded view of an encapsulated arrangement for a pressure contact rectifier,

Figure 3*a* shows an exploded view similar to that shown in Figure 3 but with a different semiconductor element,

Figure 4 shows an arrangement similar to those shown in Figures 3 and 3*a* in assembled form,

Figure 5 illustrates in part a further constructional form similar to those shown in Figures 1 and 2,

Figure 6 illustrates a semiconductor arrangement in disc form installed in a gas-tight manner in a housing,

Figure 7 illustrates a disc-form semiconductor arrangement showing a further method of installation,

Figure 8 illustrates the installation arrangement of Figure 7 applied to the semiconductor arrangement of Figure 2,

Figure 9 illustrates an installation arrangement similar to Figures 7 and 8 in which the elements of the semiconductor arrangement are differently arranged.

Referring to Figure 1, there is shown in portion of the metal housing, which may consist of copper, for example, i.e. that portion 1 of the copper housing which is pressed at its upper face against the porous sintered disc 2 for the contact making. Situated on the other side of the contact face of the sintered disc is the silicon disc 3 which is doped on both sides and is metallised on its surfaces. A further porous sintered disc 4 lies on the opposite face of the silicon disc and the contact plate 5 thereon.

The stack of discs may be pressed together in the housing by means of a spring, for example a dished spring. One current lead-in is formed by the metal housing, and the other extends from the contact plate 5 through the housing by way of an insulated bushing.

Referring to Figure 2, a molybdenum disc 8 is alloyed to the silicon disc 9 containing a pn-junction. The two discs 8 and 9 are disposed between the porous pressure-contact discs 7 and 10. The latter are in turn enclosed between the housing part 6 and the pressure-contact plate 11 and compressed. In the assembly, the individual discs are centered, for example perpendicularly to their stacking direction, for example by a ring of insulating material, such as steatite, which surrounds them at their periphery.

Referring to Figure 3 the thick-walled base portion 12 consists of a material which is a good heat conductor, for example copper. Disposed on a pedestal portion 12*a* is a sintered porous intermediate plate 17 according to the invention, and on the latter the actual semiconductor arrangement 14, 15, 16. The molybdenum disc 14 is alloyed to the silicon disc 15 by means of an aluminium layer (not shown). A gold-antimony foil 16 is alloyed into the upper face of the silicon disc. This is in turn followed by a porous sintered disc 17*a* according to the invention, on which there is disposed the copper pin 18.

In the other constructional form illustrated in Figure 3*a*, a porous sintered disc is employed only on one side, between the pressure-contact faces of the molybdenum disc 14 and the copper base body 12*a*. In this case, the molybdenum disc 20 hard-soldered to the copper pin 18 forms the upper contact without a disc 17*a* of the upper electrode of the semiconductor element. The annular disc 21, an insulating disc 22 (for example of mica), the steel disc 23 and the three dished springs 24, 25, 26 are mounted on the pin 18. When the springs have been gripped by the retaining member 27, the edge 13*a* is flanged over.

In accordance with a further constructional variant, the porous sintered disc 17*a* could be pressed onto the molybdenum disc 20 and then sintered thereto.

Figure 4 also shows the housing part consisting of the individual parts 28, 29 and 30, which is held by the flanged-over edge 13*b* of 12. The parts 28 and 30 consist of steel or of an iron alloy, and the part 29 of an insulating material (ceramics).

Referring to Figure 5 which illustrates a further constructional form the sintered disc

is formed of two layers and consists of a silver-graphite layer 32 and of a pure silver disc 33 situated on the component elements 34, which are constructed in the usual form.

Referring to Figure 6 the semiconductor element consists of a silicon plate 36 of weakly doped electrical conduction type, into which an aluminium electrode 37 has been alloyed from one surface, and a gold-antimony electrode 38 from the other surface, in order to create in the semiconductor body the desired doped regions for the formation of a pn-junction and of the internal structure of a diode. Situated on the upper face of the gold-antimony electrode 38 are a silver plate 39 and a molybdenum plate 40, which are joined together by a layer of hard solder. On the lower face, the silicon disc 36 is soldered to a molybdenum plate 41 through the aluminium layer 37.

The semiconductor element is enclosed in a gas-tight housing which consists of an insulating ring 42, for example of ceramic material, to the upper face of which there has been soldered, after metallisation of the latter, the edge of a dished cover plate 44 consisting of ductile material, for example silver.

After metallisation of the lower face of 42, a ring-shaped body 45 has been secured thereto by soldering as a metallic fitting portion. There is denoted by 43 a further cover plate of the housing, i.e. the lower cover plate, which may also consist of a ductile material, such as silver. It is initially soldered to an annular disc 46 which has then been connected in gas-tight manner at its outer edge to a corresponding edge portion of 45, for example of shielded arc welding. The dished portions of 43 and 44 are so shaped that they ensure an orientation of the semiconductor element 35 in the housing, because the semiconductor element bears by the end faces of its members 40 and 41 on the respective bases of the dished portions, and the edges rising from these base portions ensure centering of the semiconductor element in the housing.

There acts as a pressure plate on the outside face of the lower housing cover plate a cooling plate member 47 which may at the same time be an electrical connecting conductor of the semiconductor element. The upper face of the said plate member is so shaped that it is centered in relation to the cover plate 43 of the housing owing to the shape of the said face.

A pressure plate 48, which may at the same time be a cooling plate, co-acts with the upper cover plate 44 of the housing, but only indirectly through a porous sintered plate 49, for example of pure silver. However, the pressure plate 48 is now rounded in its central portion in the direction of the semiconductor element, so that it can to some extent adjust itself on this face in relation to the neighbouring body by a pivoting action. The porous sintered plate 49 enables the rounded layer face of 48 to be pressed over a large area into the upper face of 49, and at the same time renders possible a good surface engagement between the lower face of the porous sintered plate 49 and the outer end face of 44.

Figure 7 illustrates a further semiconductor arrangement comprising porous sintered discs according to the invention in the disc cell. The silicon disc 3 doped on both sides is situated between the porous sintered discs 2 and 4. In the construction according to Figure 7, the semiconductor arrangement indicated in Figure 1 is installed in the pressure-contact disc cell consisting of the two metal diaphragms 71, 72 and the body 73 of insulating material.

Figure 8 illustrates a pressure-contact disc cell with the semiconductor arrangement according to Figure 2. The silicon disc 9 is here alloyed with aluminium to a molybdenum disc 8, and the upper face with a gold tin foil. This semiconductor arrangement is compressed in the disc cell between the two porous sintered discs 7 and 10. In accordance with a further constructional form, the arrangement illustrated in Figure 8 may contain only one porous sintered disc, for example between the molybdenum disc 8 and the metal diaphragm 81.

In addition to the use of the porous sintered discs within the pressure-contact semiconductor arrangements for producing a good heat transfer, porous sintered discs may also be mounted outside the semiconductor arrangements against the cooling body. Figure 9 illustrates a pressure-contact disc cell 91 which is gripped between the two porous sintered discs 92 and 93 and the two cooling bodies 94 and 95.

WHAT WE CLAIM IS:—

1. A semiconductor component including a pressure-contact junction which incorporates a sintered porous disc of good electrical and thermal conductivity, as an intermediate or junction body.

2. A semiconductor component according to claim 1, wherein the disc has a porosity between 2% and 40%.

3. A semiconductor component according to claim 1 or 2, wherein the disc consists of sintered metal or sintered metal alloy and is readily plastically deformable.

4. A semiconductor component according to any one of claims 1 to 3, wherein the sintered disc consists of a porous composite material of a metal or a metal alloy and a lubricant component finely and uniformly distributed therein.

5. A semiconductor component according to claim 4, wherein the lubricant is

graphite, molybdenum (IV) sulphide, or tungsten selenide.

6. A semiconductor component according to any one of claims 1 to 5, wherein the sintered disc has a thickness between 0.1 and 2 mm.

7. A semiconductor component according to any one of claims 1 to 4, wherein a sintered silver disc is employed.

8. A semiconductor component according to any one of claims 1 to 4, wherein the sintered disc consists of silver having inclusions of finely divided graphite.

9. A semiconductor component according to claim 1 or 2, wherein the sintered disc consists of two layers of different sintered materials.

10. A semiconductor component according to claim 9, wherein the two layers of the sintered disc consist of two different metals.

11. A semiconductor component according to claim 9, wherein one layer of the disc consists of a metal and the other layer of a metal with added lubricant component.

12. A semiconductor component substantially as hereinbefore described with reference to any one of Figures 1 to 3, Figures 3*a* and 4 or any one of Figures 5 to 9 of the accompanying drawings.

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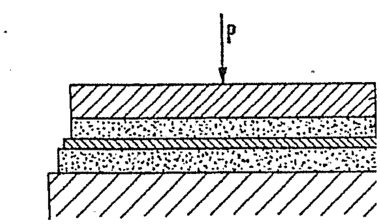
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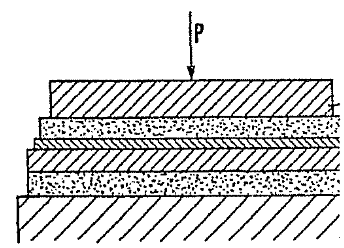
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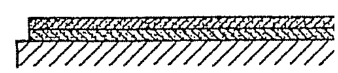

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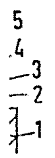

Fig. 1

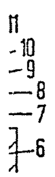

Fig. 2

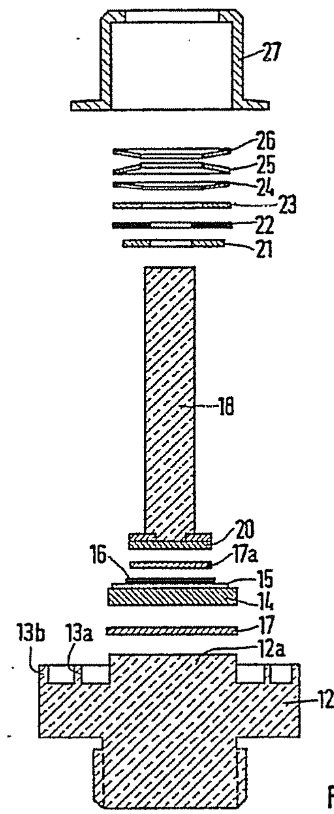

Fig. 3

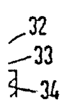

Fig. 5

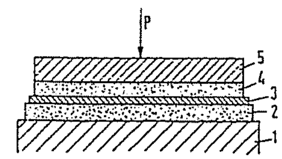

Fig. 1

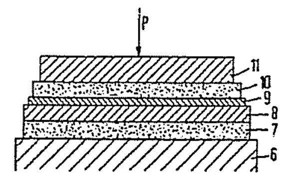

Fig. 2

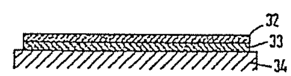

Fig. 5

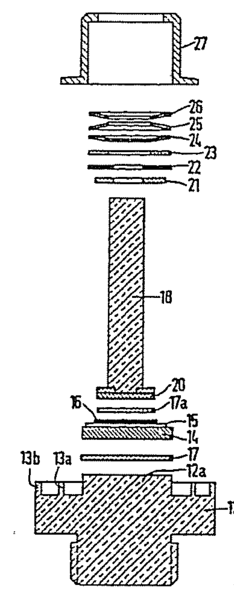

Fig. 3

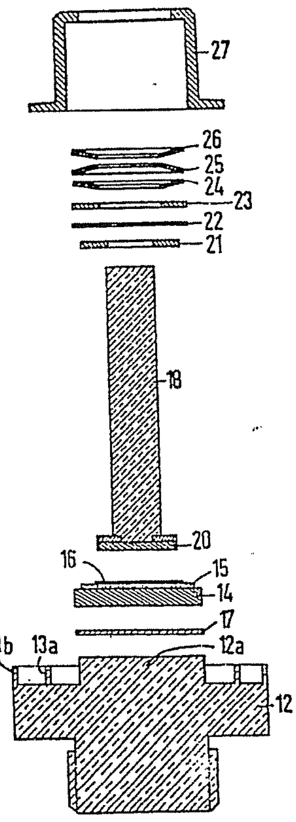
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Fig. 3 a

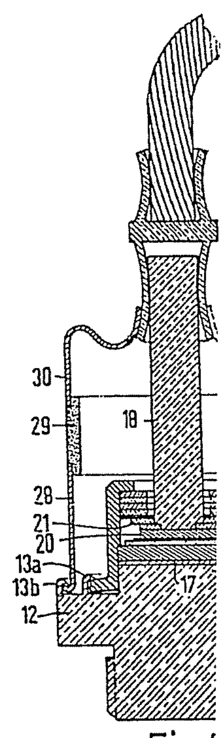
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Fig. 4

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Sheets 3 & 4

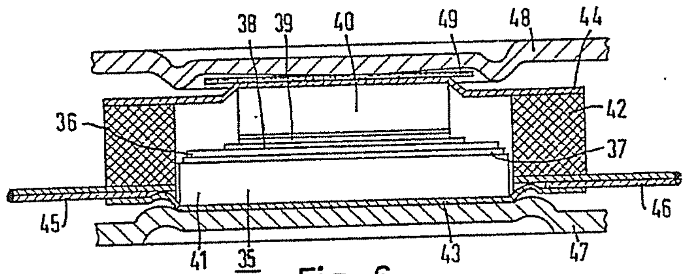


Fig. 6

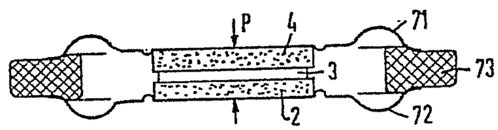


Fig. 7

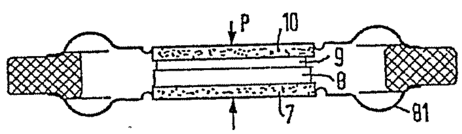


Fig. 8

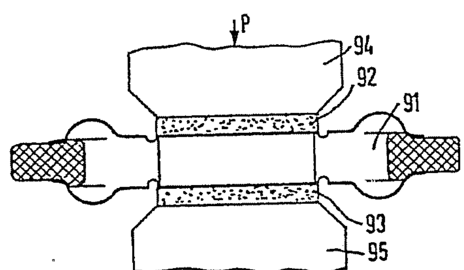
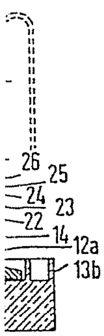


Fig. 9



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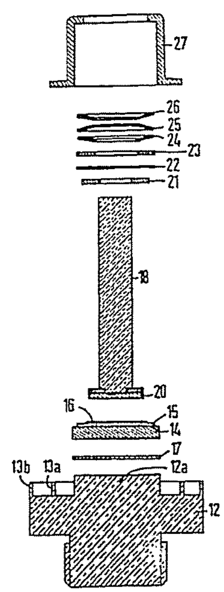

Fig. 3a

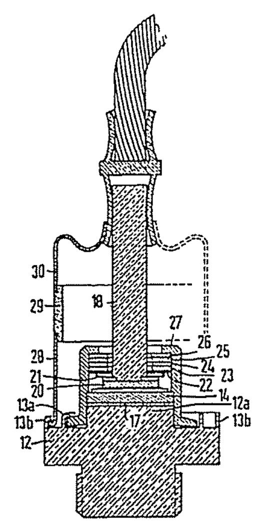

Fig. 4

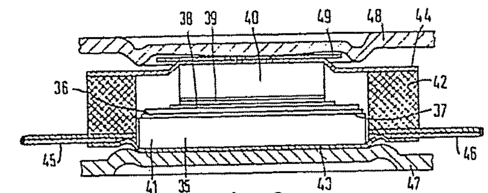

Fig. 6

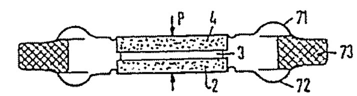

Fig. 7

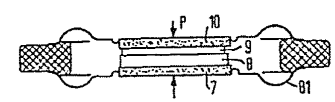

Fig. 8

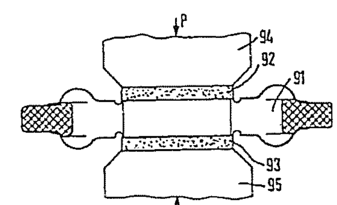

Fig. 9